“Working on Mars”

Understanding How Scientists, Engineers and Rovers Interacted Across Space and Time during the Mars Exploration Rover Mission

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Overview

- Description of
  - Ethnographic Methods for NASA
  - “Mission” Ethnography
  - Assessing a Work System
- Scientists, Engineers and Rovers Working “on” Mars- what can ethnography uncover?
  - Overview of a MER work day
  - Facilities for “seeing” a distant landscape and collaborating
  - How do teams communicate with each other and the rover on Mars
  - Working on Mars time: Keeping track of time

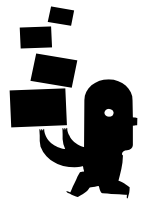
Ethnographic Methods for NASA

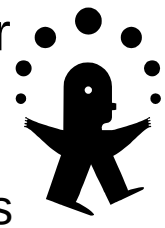
- Data collection and analysis of:
  - field notes from in-situ observation and participation
  - video and photos
  - documents and artifacts
  - information created in software
  - system interactions between tools
  - information exchanged in meetings
  - nature of individual and group work
  - Interviews (formal and informal)
  - Email information and exchanges
  - Continuous feedback loop with users and participants

Assessing a Work System: Where to Begin?

Assessing a Work System: Where to Begin?

- Work System Analysis
  - What is the organizational structure?
  - What tools do people use? How do people access, display and share information?
  - What information is in the software? What should be in the software?
  - How do people communicate?
  - What are the described processes (work process) vs. actual work (work practice)
  - What are the breakdowns and disconnects? What is the re-work or workarounds?
  - When and where are decisions made? Who is responsible for what?
  - How do the facilities support the work?
    - Rooms, work stations, tables, chairs, printers, projection screens
  - What is missing?
    - Minimal support of standard information sharing formats: ex: Copiers and Printers not easily accessible, etc.





“Mission” Ethnography at NASA

Rules of Mission ethnography:

1. If you have a badge and are taking up room in meetings or tests, you must contribute and add value.
2. Launch, landing and surface operations will meet the mission timeline whether you contribute or not.
3. Feedback that is late is useless; input on software development, systems integration and training must meet the above timelines.
4. Mission personnel will remember if you contributed or not and this will influence their future interactions with you. (See 1 above)
5. Processes and Procedures will be re-worked into the mission. They are the only thing that does not have a freeze and change control limitations.

Mars Exploration Rover Mission (MER)

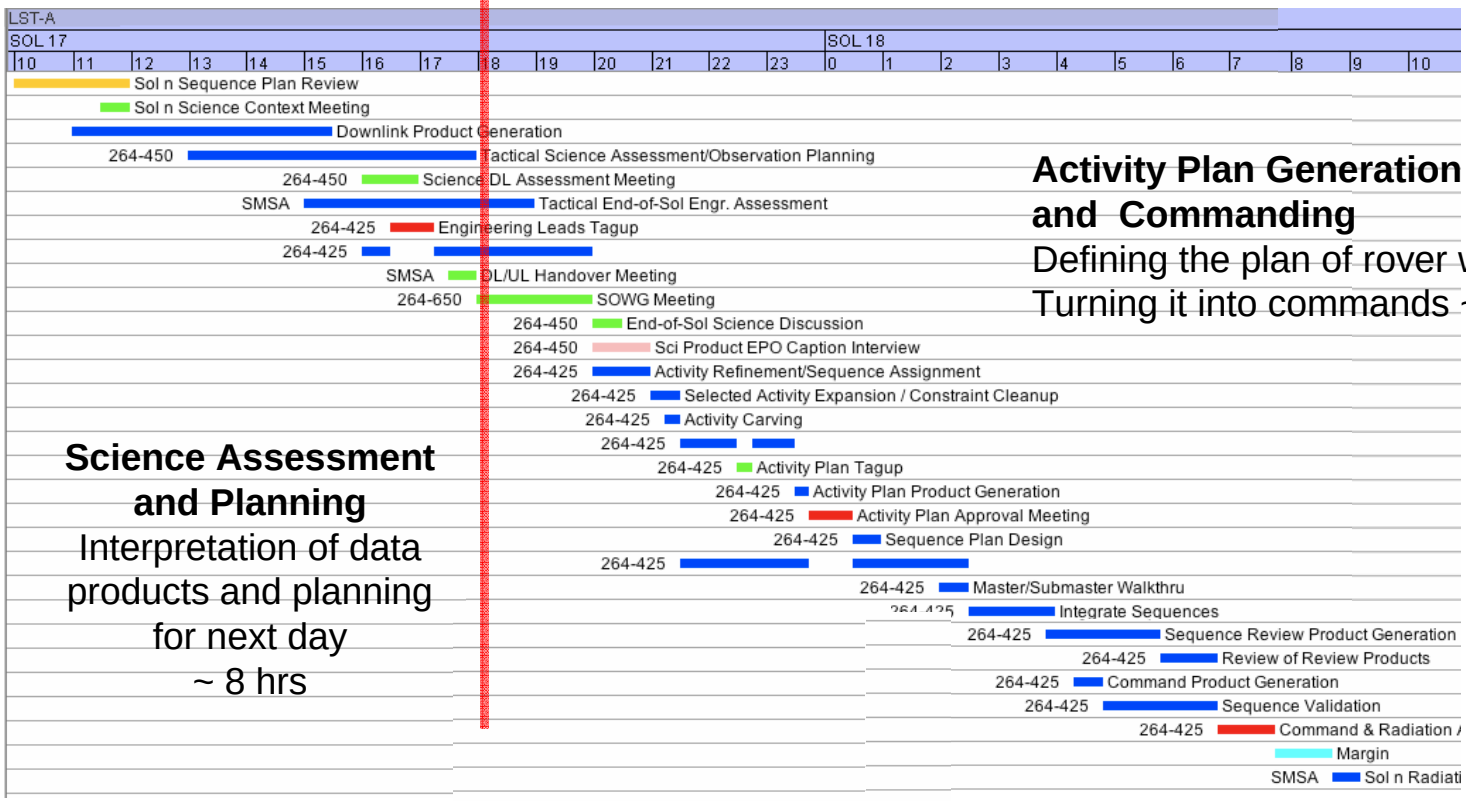
- **Science Mission**
  - **Launched: Two rovers June/July 2003**
  - **Landed: early and late January 2004**
  - **Run for NASA by Jet Propulsion Lab (JPL) in Pasadena, CA. Ames contributed to the mission.**
  - **Mission run on Mars time (Martian sol = 24:39 in Earth time)**
    - **Solar powered rovers**
    - **Sunlight and daytime temperatures for cameras and other instruments**
  - Objective: search for evidence of past water
- **Work Cycle**
  - **Activity Planning for rover work and batch of commands sent every sol for rover execution on the next sol**
  - **Nominal mission lifetime 90 sols per rover, spanning four months January thru April**

Daily/ “Soly” Timeline for Work, Planning and Commanding

- Day/Sol split into two phases:

Downlink: Receive data from the rover, do health validation and data product generation. Decide on and generate science plan requests

Uplink: Prioritize, constrain, plan rover activity. Generate, validate, and transmit commands to the rover



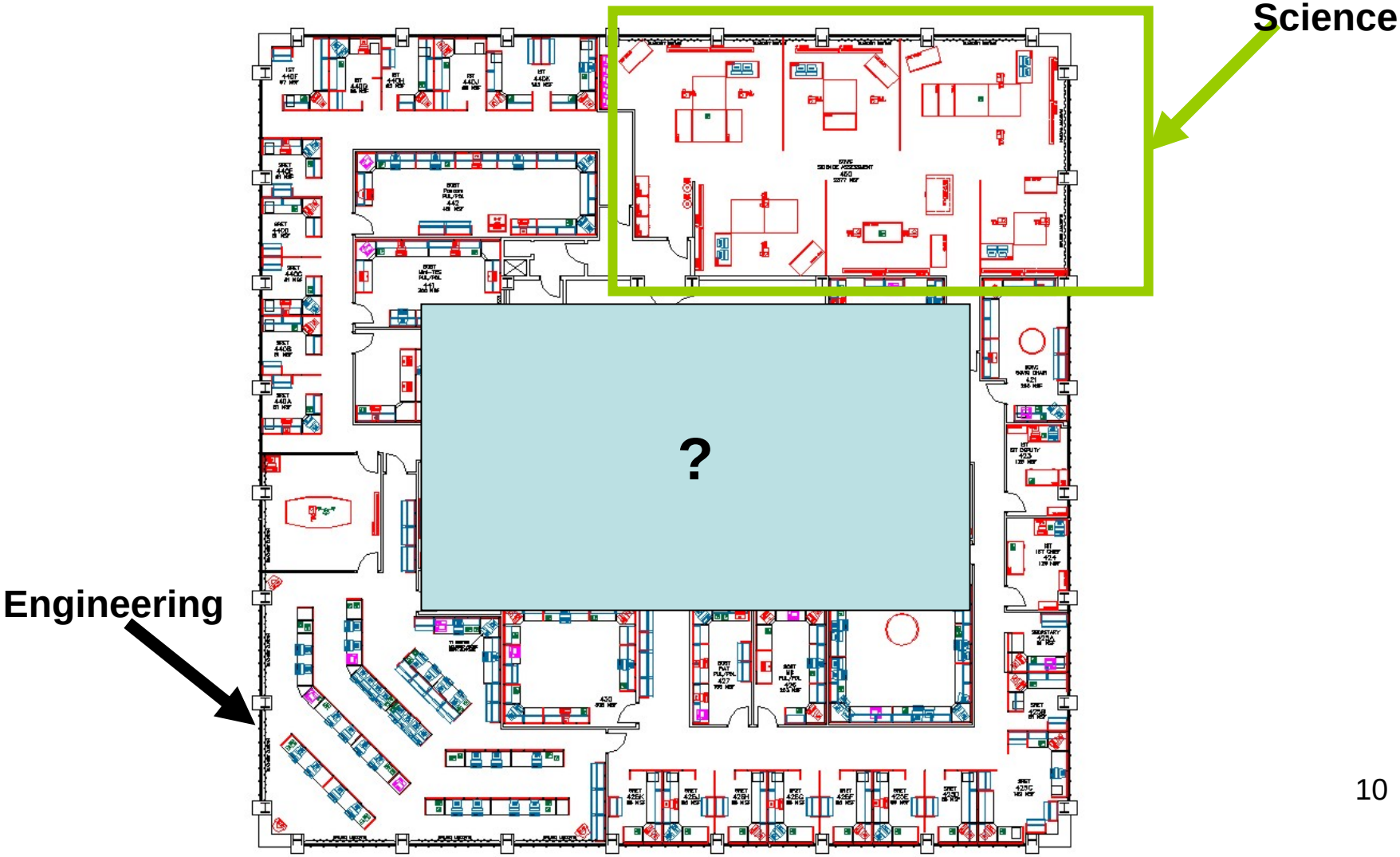
Science Assessment and Planning
Interpretation of data products and planning for next day
~ 8 hrs

Activity Plan Generation and Commanding
Defining the plan of rover work and Turning it into commands ~ 14 hrs

Facilities Design

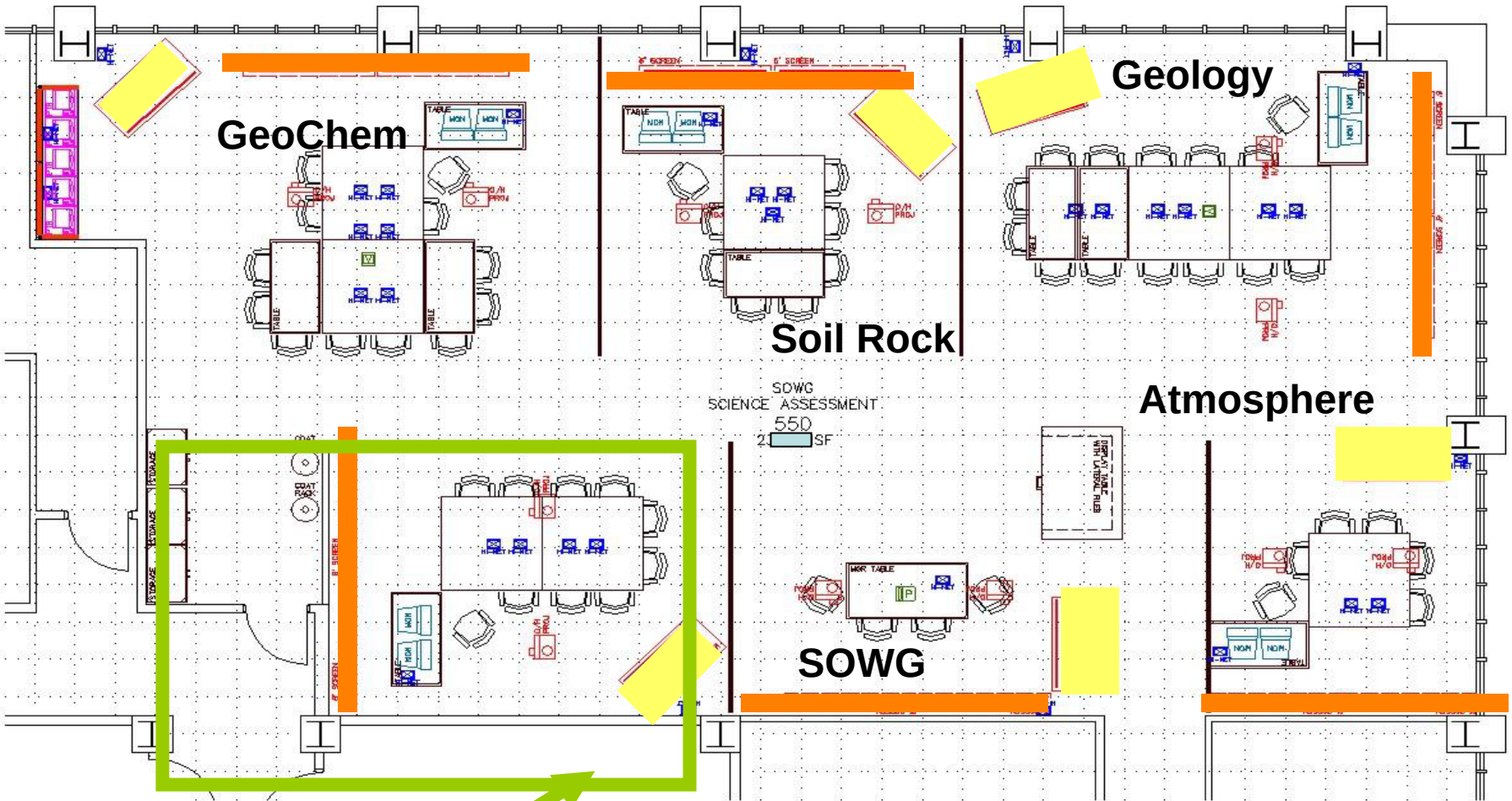
- Where is this work done?
- How do you support tele-robotic science so that people can:
  - know what is happening on Mars
  - share and see information
- How do you support collaboration?
- What are some of the more interesting ways in which the facilities contribute to the work?

Facilities: Mission Support Area (MSA)-Bird's Eye View



Facilities: Science Assessment Room

Five Theme Groups- Planning for collaboration and work



Long Term Planning Area

Facilities: Science Assessment Room

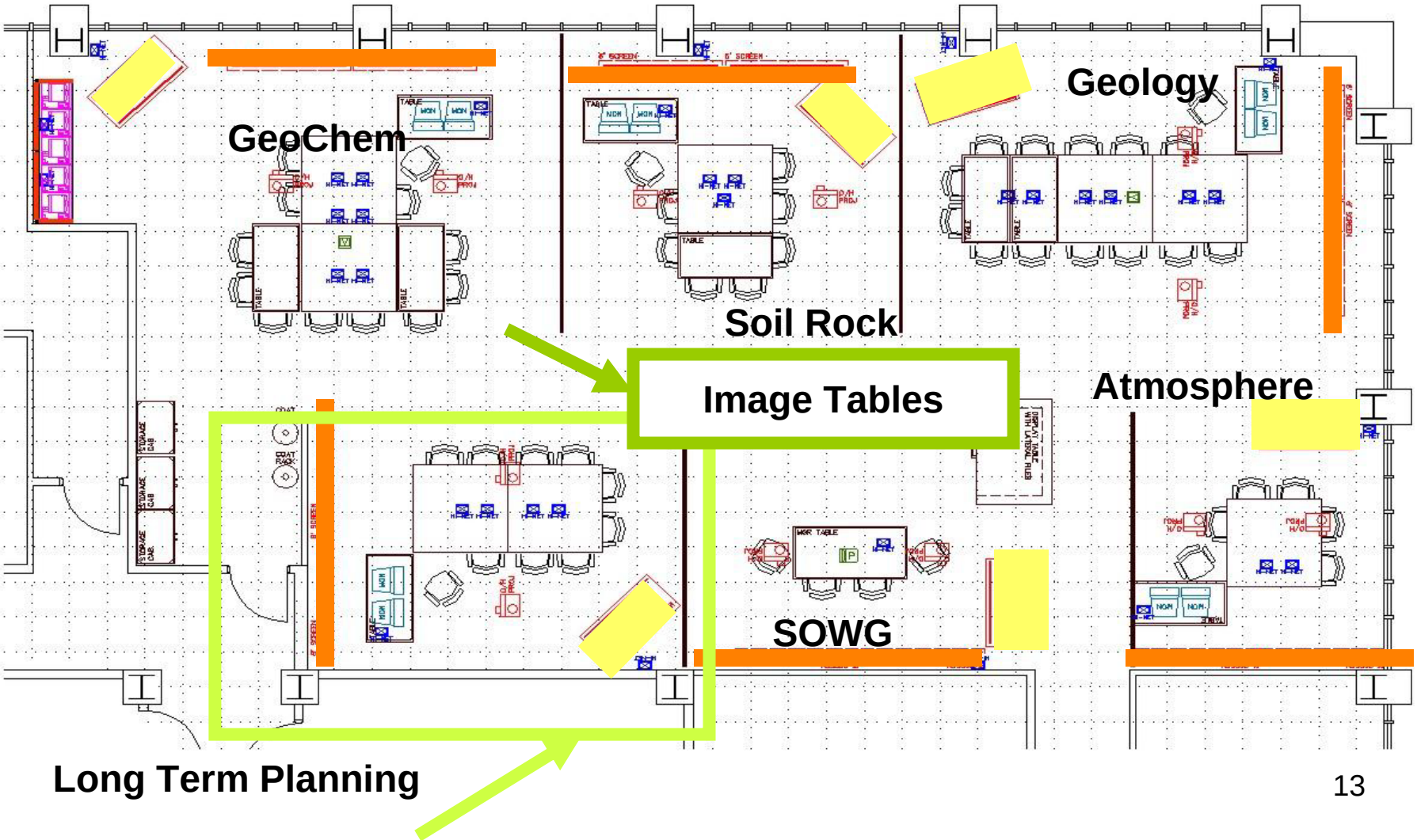


Image Tables: A “Window” on Mars

Virtual Reality vs. Printed Images

Communicating Across Teams and with the Rover-The Problem

- Problem: how do you convey information across teams and to a rover, when:
  - participants speak different technical languages
  - focus on different issues
  - have different tasks
  - use different software tools
  - must communicate from humans to a robot
- Not just an academic exercise, the answer influenced mission software design

Communicating Across Teams and with the Rover- the Problem

Science Team

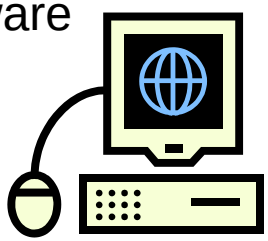
Natural Language Discussion

Science Request/ Planning Software

Science Planning Meeting

Engineering Team 1

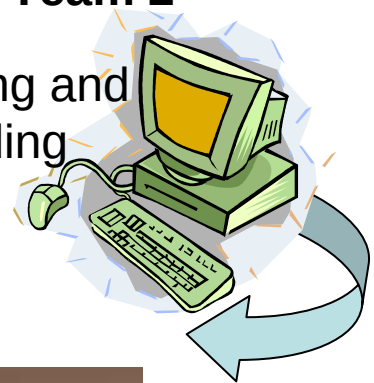
Rover Activity Planning Software



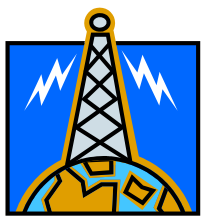
Rover Activity Plan Approval

Engineering Team 2

Sequencing and Commanding software



Command Approval Meeting



Time delay

Radiate to Rover on Mars

Communicating Across Teams and with the Rover- An Answer

- Answer: Identify a “naming convention” that describes the work and
  - allows for natural language discussion
  - identifies components that are relevant to all teams Ex: instrument
  - identifies formalized concepts Ex: methods, feature, target
  - Carries within and across software tools
  - can be translated into work for the rover

Mars Time - Keeping Track of Time

- Martian sol = 24:39 minutes in Earth time
- Mission works on Mars Time
- Participants report at the same time on every Martian sol: 12:00 hrs.
  - But to do that they have to keep track of ever changing Earth date, hour and minute
  - Report to work 39 minutes later every day in Earth time: 12:00, 12:39, 13:18, 13:57, 14:36 etc
  - Schedules help keep track

Earth Time, Mars Time, Keeping Track of Time

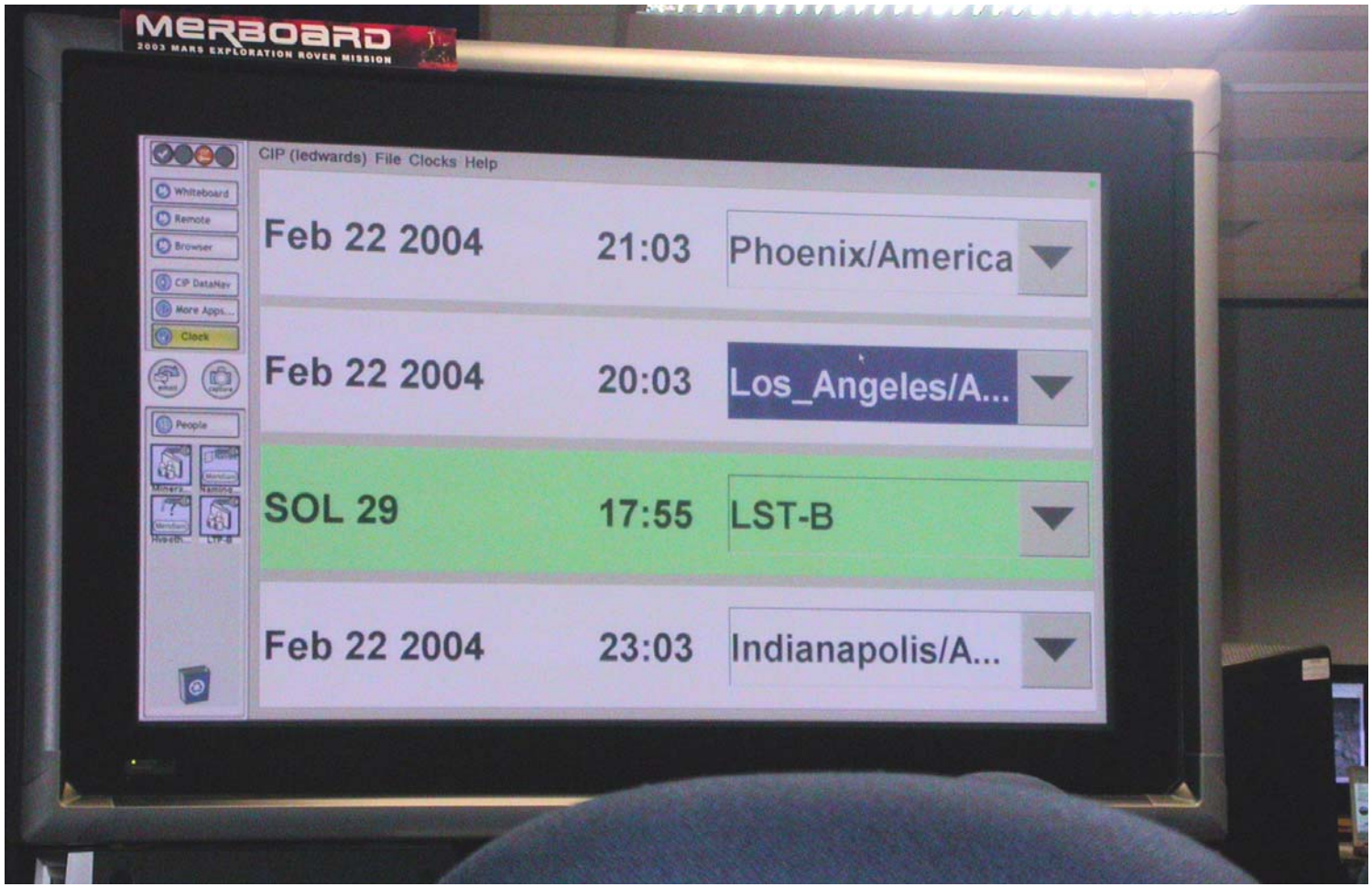
MER A				
Date [PDT] @ PDL Shift Start	1/5/04 15:08	1/6/04 15:48	1/7/04 16:27	1/8/04 17:07
Approx. Sol	3	4	5	6
Pancam PEL	JBe	JBe	JJo	JJo
Pancam PDL	MLe	MLe	RMo	WFa
Pancam PDA	JSo	FSe	FSe	MJo
Pancam PDA2	MWo	WFa	MJo	JSD
Pancam PUL	JPr	JPr	HAr	HAr
Pancam PUL2	EMc	MBM	JPr	MBM

Courtesy of MER Pancam Team and J. Bell

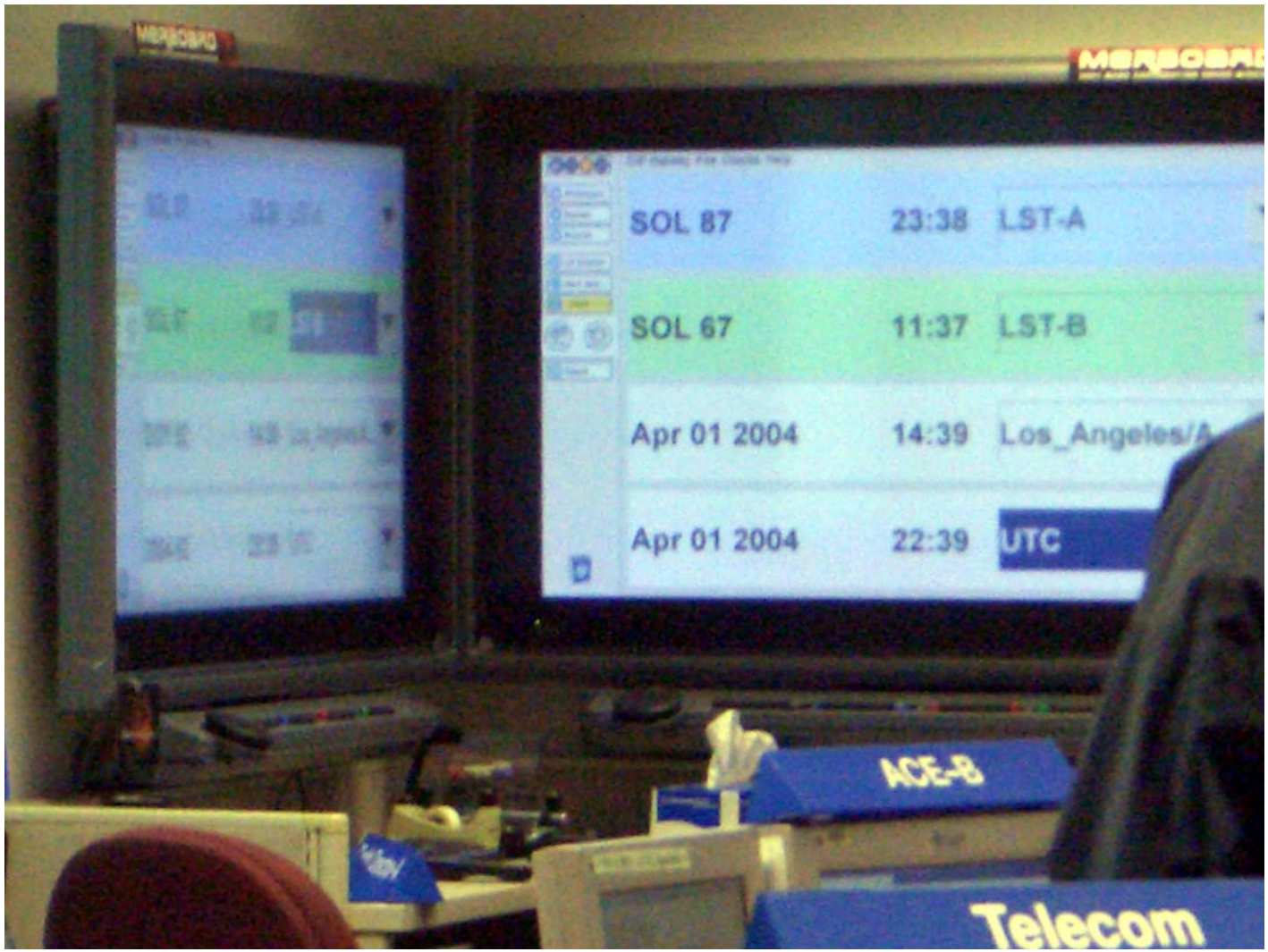
Earth Time, Mars Time, Keeping Track of Time

- Not just schedules keeping track of time meant knowing:
  - LST for each mission (local solar time on Mars at each site)
  - Relationship between LST A and LST B (twelve hours *and* 20 sols apart)
  - Relationship between LST and PST (what time it is in the “outside” world)
  - UTC (Universal Time Coordinated for radiating commands to Mars)
  - Military time (for aligning Earth and Mars time work within the mission)
  - Time in other Earth time zones (for scientists working with people at home institutions)
  - Relationship between Sol (1, 2, 3) and Earth date (1/5/04)

Earth Time, Mars Time, Keeping Track of Time- Clocks!



Earth Time, Mars Time, Keeping Track of Time – Clocks!



Earth Time, Mars Time, Keeping Track of Time

Quote found written on white board by MER participant :

What time is it in reality?

Lesson Learned - Versatility in the Method

- Ethnographic methods can:
  - be applied in any domain
  - uncover findings in diverse areas in the same domain
  - help “outsiders” understand a new domain
  - help “insiders” understand their own world more fully and improve it